



The recent invasion of the citrus flower moth, *Prays citri* (Millière, 1873) (Lepidoptera: Praydidae) in Iran

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ABSTRACT. The larvae of a moth feeding on the citrus flowers specifically on, *Citrus limon*, were found in greenhouses in Mazandaran province (north of Iran) in April 2024. Based on the habitat preference, and the morphological features, larvae and pupae were identified as *Prays citri* (Millière, 1873) (Lepidoptera: Praydidae). This species was listed among the foreign quarantine pests of the country, according to the guide list for monitoring and tracking quarantine agents of Iran on 21 June 2024. It is one of the most harmful pests of citrus plants especially lemon, which is spreading rapidly and creepily in all areas in the world. Our recent evidence revealed the existence of this pest in a moderately wide area of the Iranian northern lemon greenhouses. Background information for a reliable identification of both adults and larvae, the taxonomic history, origin, distribution, host plants, damage, and management practices of the pest are also discussed. The occurrence of this pest is a warning for Iranian citrus orchards indicating a potential risk of its spread, particularly to the southern regions of the country.

Keywords: Alien species, citrus pests, quarantine pests, greenhouses, lemon

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INTRODUCTION

Citrus orchards are considered the major fruit crops in Mazandaran (North of Iran), due to the cultivated area reaching 276 000 ha representing about 26% of the total fruit area (Nourmohammadpour-Amiri et al., 2022). In recent years, the greenhouse cultivation of lemon trees in Mazandaran province has received much more attention. Lemon (lime) greenhouse cultivation started in 2011 in this province and has reached its peak in the last few years. In a short period, hundreds of farmers and gardeners have applied for a license to build lime greenhouses. Khormakali village of Qaemshahr is one of the pioneers in the production of this best-selling product in the province with the license to establish 150 lime greenhouses (Mozaffari Savadkahi, 2024). Several pest species have invaded the agricultural landscapes in the

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northern provinces of Iran during the last few decades (Nourmohammadpour-Amiri et al., 2022). Some invasions were attributed to climate change or natural colonization, while others were facilitated by the human introduction of exotic plants (Tamutis et al., 2022). The expansion of certain exotic lepidopteran species, such as *Cydalima perspectalis* (Walker, 1859) (Crambidae) and *Hyphantria cunea* (Drury, 1773) (Erebidae), has been regrettably successful. Additionally, these species have emerged as some of the most dangerous pests globally, including in Iran (Moradi Afrapoli et al., 2022).

It appears that the rise in lemon greenhouse cultivation has led to the introduction of new exotic lepidopteran species to the list of agricultural pests in Iran. Early detection and accurate identification of potential pests are crucial steps in preventing population outbreaks and minimizing significant damage (Tamutis et al., 2022). The initial population of *P. citri* was collected in the early months of 2024, and the identification of the species was conducted at that time. However, due to the necessity for a more precise comparison, we temporarily halted the dissemination of this information. During this period, the occurrence of this species was reported by Alipanah et al. (2025) from Sari. Therefore, in this paper, we are limited to providing supplementary information on the range of distribution, general morphology and ecology, and possible routes of invasion and expansion of the citrus flower moth, *P. citri*, in Iran. It also highlights the potential for this pest to spread to other regions if not regularly monitored and controlled.

MATERIAL AND METHODS

The field surveys took place at the end of April 2024 in three lemon greenhouses (*Citrus × limon*), Esfandan village (Kilometer 17 Khazar Abad Rode, 500 m²), Zaghmarz (2000 m²) and Chubagh village (4 ha, Kilometer 30 Khazar Abad Rode). The larvae feeding on the flower were collected and preserved in 70% EtOH. Adult moths were collected using light traps established in the same greenhouses. Furthermore, some specimens were reared to adults from the infested blossoms in the laboratory. The diagnosis of adults and larvae was extracted from the recent description by Wheeler et al. (2025). All studied materials (adults, larvae, and pupae) are deposited in the entomology laboratory in the Department of Plant Protection of Sari Agricultural Science and Nature Resources University (SANRU).

RESULTS

The collected materials were identified as citrus flower moth, *Prays citri* (Millière, 1873) belonging to the family of Praydidae Moriuti, 1977.

Taxonomic hierarchy

Class Insecta Linnaeus, 1785

Order Lepidoptera Linnaeus, 1785

Family Praydidae Moriuti, 1977

Genus *Prays* Hübner, 1825

***Prays citri* (Millière, 1873) (Figs 1, 2)**

Material examined. 6 ♀/♂, Iran, Mazandaran province, Sari, Esfandan village (Mr. Akbarzadeh greenhouse), lemon greenhouse, 36°44'3.4"N, 53°07'4.6"E, -17 m a.s.l., 25-IV-2024, leg.: Fardin Shahbaznejad. 5 ♀/♂, Iran, Mazandaran province, Sari, Zaghmarz (Mr. Abdollahi greenhouse), lemon greenhouse, 36°47'44.9"N, 53°17'35.6"E, -18 m a.s.l., 25-IV-2024, leg.: Fardin Shahbaznejad. 7 specimen, Iran, Mazandaran province, Sari, Chubāgh village (Mr. Shaeri and Larimi greenhouse), lemon greenhouse, 36°45'21"N, 52°58'27"E, -23 m a.s.l., 27-IV-2024, leg.: Masoumeh Shayanmehr.

Morphology. The adults (male/female) with long and filiform antennae. Wingspan 12–14 mm. Head, thorax, and forewings greyish-brown, forewings narrow and pointed, spotted with dark, hind wings brownish with narrow, pointed with long fringes (Fig. 1A–D). The larvae vary from light grey or greenish to brown. Fully grown larvae 4.2–5.5 mm long and semi-transparent (Fig. 1E–F). The pupa is initially light green but soon turns chocolate brown (Fig. 1G).

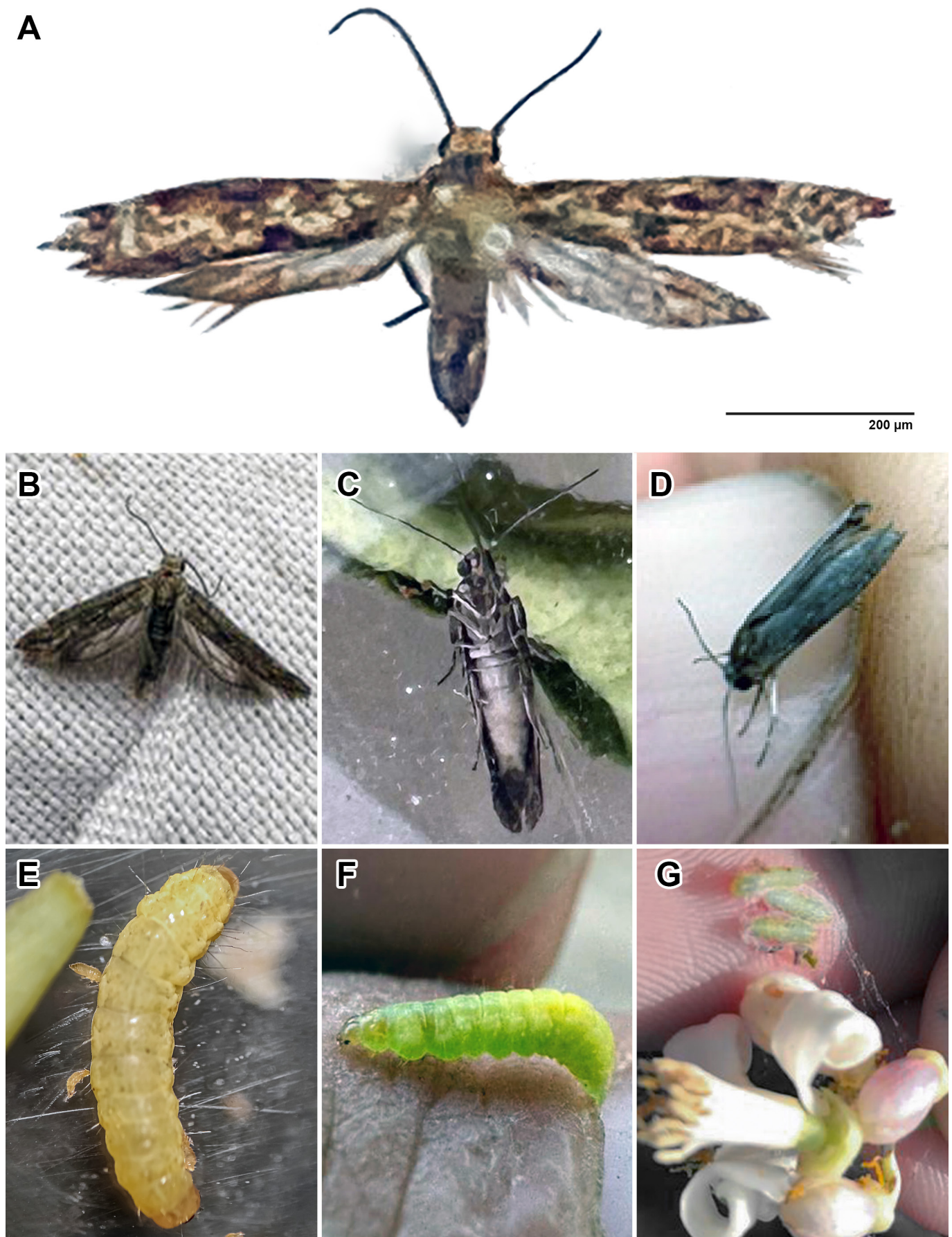


Figure 1. *Prays citri* (Millière, 1873) (Lepidoptera: Praydidae). **A-D.** Adult moth; **E.** Larvae under stereomicroscope; **F.** Larvae; **G.** Pupa in cocoon (Original).

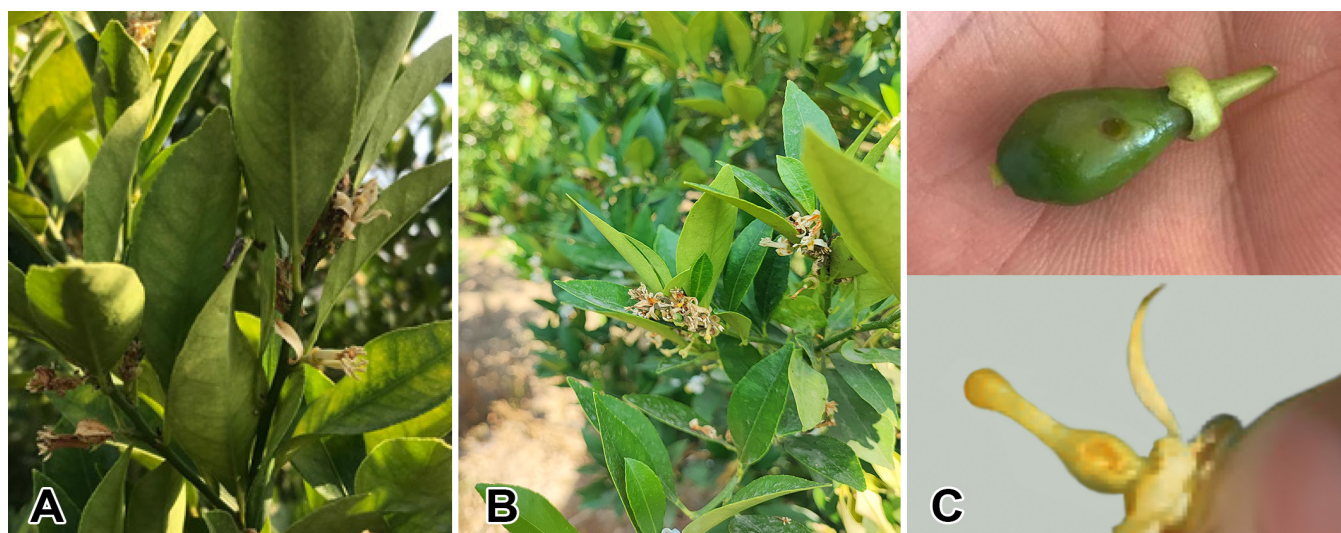


Figure 2. *Prays citri* (Millière, 1873) (Lepidoptera: Praydidae). **A–B.** The injury is caused by the larvae eating into the flower parts or by webbing them together; **C.** Penetration of the fruit by the neonate larva.

Damage and symptoms. Citrus flower moth larvae are particularly destructive to blossoms and young fruit which occur in spring and mid-summer. The damage occurs when the larvae feed on the flower parts or web them together. The larvae penetrate the buds and feed on them. As a result, damaged flower buds and flowers quickly wilt and are shed (Fig. 2A–C). The penetration of the fruit by the newly hatched larva is usually very superficial and often results in gumming of the fruit. Initially, the penetration marks (Fig. 2C) are relatively small, but as the fruit matures, they develop into brown necrotic scars, which can lead to the fruit being downgraded. Pupation occurs among damaged flowers or leaves.

Distribution in Iran. The occurrence of this species has very recently been reported from one of the studied locations (Chubagh village) in the citrus-growing regions of the north, but there is no available information on its presence in other citrus-producing provinces. This pest likely entered from Iran's neighbouring country, Turkey, along with infected saplings of lime trees.

General distribution. The pest, citrus flower moth has been widespread throughout the world, especially in the Mediterranean regions (Fig. 3).

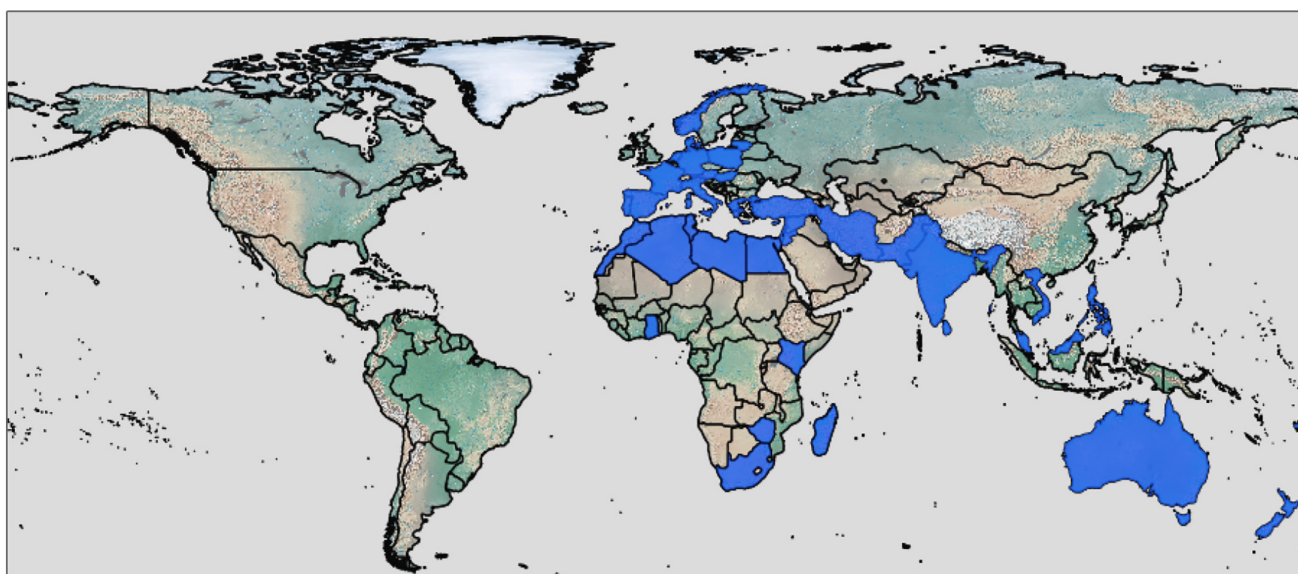


Figure 3. Distribution of *Prays citri* in the world. The infected regions are shown in blue colour. (Map extracted from <https://www.simplemappr.net>)

DISCUSSION

The citrus flower moth, *Prays citri* (Millière, 1873) (Lepidoptera: Praydidae), was found in three lemon greenhouses in Mazandaran province. Species of the family Praydidae are a group of Yponomeutoidea, whose systematic position has remained uncertain for several years (Sohn & Wu, 2011). In the last century, two opinions of their placement in Yponomeutoidea were prevalent: i.e. as a sub-family of Yponomeutidae (Kyrki, 1990; Dugdale et al., 1998) or as a subfamily of Plutellidae (Heppner, 1998; Sohn & Wu, 2011). Recently a status as a separate family has been proposed based on a rigorous molecular phylogenetic study (Mutanen et al., 2010). The members of this family can be recognized by their unique modification of the eighth abdominal segment and by their genitalia. The broadly enlarged male sternum VIII and the greatly reduced female apophyses ante-riores are among these characteristics (Kyrki, 1990; Sohn & Wu, 2011). The family Praydidae, established by Moriuti in 1977, comprises about 60 species worldwide classified into 5 genera (Karsholt & Razowski, 1996) with 8 species recorded from Europe (Landry et al., 2023). Adults of the *Prays* species are not readily conspicuous and thus they are often neglected in field collecting or during specimen curation (Landry & Landry, 1998; Agassiz, 2007; Sohn & Wu, 2011). The *Prays*-group is a complex species which represented in almost all zoogeographic regions but the species are regionally concentrated (Mutanen et al., 2010; Sohn & Wu, 2011).

Species of the genus *Prays* are considered serious pest species, the olive moth *P. oleae* (Bernard, 1788), and the citrus flower moth, *P. citri* (Millière, 1873) can cause serious economic losses in agriculture (Carter, 1984; Fazekas, 2022). The latter demonstrates the possibility to spread and survive in greenhouses in some Central and even Northern European countries (Buhl et al., 2019; Gustafsson & Malm, 2025). The pest has been reported in many countries and the invasion of this pest is increasing rapidly (Fazekas, 2022; Tamutis et al., 2022). *Prays citri*, a newly recorded species from Iran is an important pest species in the Mediterranean region (Alipanah et al., 2025). *Prays citri* feeds on various host plant families, Rutaceae and Sapotaceae (*Manilkara zapota*, *Casimiroa edulis*), as well as Oleaceae (*Ligustrum lucidum*) (Fazekas, 2022). However, the most significant economic damage caused by *P. citri* has been reported on lemon, *Citrus limon* and lime, *C. aurantiifolia* trees, with occasional attacks on king orange (*C. reticulata* × *sinensis*), orange (*C. tangerina*), mandarin orange (*C. reticulata*) (Balachowsky, 1966) (Garrido et al., 1984), citron (*C. medica*), sweet oranges (*C. sinensis*) (Ibrahim & Shahateh, 1984) and cedar trees (Pinaceae) (Prinsloo & Uys, 2015). The damage caused by *Prays citri* on *Citrus limon* (lemon) is particularly concerning, as it could lead to a loss of up to 90% in Spain and 15–70% in flower production in Portugal, respectively (Garrido et al., 1984). Additionally, *P. citri* is also regarded as an economically important pest on lime trees in Egypt (Ibrahim & Shalateh, 1984). It is worth noting that in the three study sites, there were other host plants of Rutaceae around the greenhouses. However, based on our observations and those of the gardeners, the lemon trees, *C. limon* appear to be the preferred host of *P. citri* which should be confirmed through future experiments. The chances of survival of the *P. citri* inside e.g., in the lemon greenhouses are quite high because trees bloom several times a year in the greenhouse. Conversely, the risk of its spread outdoors is low due to the absence of preferred hosts and stable temperatures. This risk may be exacerbated in particular by the warming of the climate and the popularity of the cultivation of exotic plants in greenhouses worldwide (Tamutis et al., 2022).

After reporting the *P. citri* as a new pest in lemon orchards, the next step is to study its life history. The life cycle of this moth has not been extensively researched in many regions worldwide. While the pest is primarily found in nurseries and herb gardens, it can also thrive indoors. It overwinters in temperate, heated environments (Fazekas, 2022). In the Mediterranean region, all life stages of the insect can be observed year-round. The number of generations varies from 3 to 16, depending on climatic conditions. Females typically lay their eggs on flower buds; these eggs are approximately 0.2 mm long, slightly oval, and white or creamy-white in colour. Population levels tend to be low during winter and spring but increase significantly during summer and autumn. Development begins at a threshold temperature of around 10°C, with the first attacks occurring in spring as temperatures rise above this threshold (Prinsloo & Uys, 2015). The citrus flower moth has spread widely across various regions, including Africa, Europe, and Asia, with a notable presence in Turkey, Pakistan, Israel, India, Lebanon, Jordan, and Syria (Balachowsky, 1966; Carvalho et al., 1997; Prinsloo & Uys, 2015; Fazekas, 2022).

In Iran, this species has likely been introduced to all citrus-growing areas in the northern part of the country, possibly entering from neighbouring countries such as Turkey where it was probably introduced with some citrus varieties (Balachowsky, 1966; Carvalho et al., 1997; Fazekas, 2022). With the pest's arrival in Iran's northern citrus-growing regions, it is crucial to monitor its spread and prevent its movement into other provinces. In countries where the pest has already established itself, various control methods have been implemented that could also be applicable in Iran if *P. citri* becomes widespread. During spring, blossoms should be inspected for larvae presence or damage, which can be conducted alongside monitoring for other pests. A commercially available pheromone lure can be utilized in either delta or bucket traps (Prinsloo & Uys, 2015). Water stress is a significant factor in pest management for *C. limon* (lemon) agroecosystems. In Italy, orchards experiencing water stress showed total infestation levels in buds, flowers, and set fruits below the economic threshold. Conversely, orchards with adequate water supply reported infestation levels exceeding the economic threshold during the same period (Mineo et al., 1991). In some other affected countries, pest control for *P. citri* has rarely been necessary; however, if chemical treatment becomes essential, insecticides such as chlorpyrifos are commonly used against the citrus flower moth on lemon trees (Prinsloo & Uys, 2015). The pest can also be effectively managed with any organophosphate, carbamate, or pyrethroid used for controlling other concurrent pests. Treatments should target the first generation of larvae that attack blossoms to prevent the development of a second generation that could infest small fruits. Controlling eggs laid on fruit by this second generation is particularly challenging since hatching larvae penetrate directly from the egg into the fruit rind, avoiding exposure to spray residues (Prinsloo & Uys, 2015; Moore & Kirkman, 2014). In certain European countries, *Bacillus thuringiensis* was applied to control the citrus flower moth, and trial work in South Africa has confirmed its efficacy (Prinsloo & Uys, 2015). Once eggs are laid on fruit, achieving satisfactory control becomes difficult. Trials have shown that the insect growth regulator triflumuron is more effective against eggs than any other product (Prinsloo & Uys, 2015). *Prays citri* has numerous natural enemies, including predators and parasites, some of which are polyphagous and also target other species such as *P. oleae* (Mineo et al., 1991) (Table 1). However, the impact of biological control and the use of natural enemies is considered negligible in some countries, as they are often unable to control the moth effectively (Garrido et al., 1984; Uygun et al., 1995). Nonetheless, some of these natural enemies are present in Iran and could potentially be utilized against the pest.

Table 1. The representative natural enemies of the citrus flower moth, *Prays citri* (Millière, 1873) (Lepidoptera: Praydidae) in the world.

Natural enemies	Family	Impact	Occurrence in Iran	References
PARASITOIDS				
<i>Chelonus</i> spp.	Braconidae	non-specific	+	Prinsloo & Uys (2015) Iranmanesh et al. (2018)
<i>Bracon laetus</i> (Wesmael 1838)	Braconidae	Partially - specific	+	Nave et al. (2017) Iranmanesh et al. (2018)
<i>Ageniaspis fuscicollis</i> (Dalman, 1820)	Encyrtidae	partially - specific	+	Garrido et al. (1984) Fallahzadeh & Japoshvili (2010)
PREDATORS				
<i>Orius niger</i> (Wolff, 1811)	Anthocoridae	non-specific	+	Moreno et al. (1990) Darvish Mojeni (2013)
<i>Aeolothrips tenuicornis</i> Bagnall, 1926	Aeolothripidae	non-specific	+	Nave et al. (2017) Mirab-balou (2018)
<i>Galendromus occidentalis</i> (Nesbitt, 1951)	Phytoseiidae	non-specific	-	Nave et al. (2017)
<i>Chrysoperla carnea</i> (Stephens, 1836)	Chrysopidae	non-specific	+	Mineo et al. (1991) Zakerin et al. (2009)
PATHOGENS				
<i>Bacillus thuringiensis</i> Berliner 1915	Bacteria	non-specific	+	Uygun et al. (1995) Salehi Jouzani et al. (2017)
<i>Beauveria bassiana</i> (Bals.) Vuilemin	Fungi	non-specific	+	Carvalho et al. (1997) Faraji et al. (2013)

For monitoring the distribution of this pest in all citrus-growing regions of northern Iran, during spring, blossoms should be inspected for the presence or damage by larvae. By implementing internal quarantine, the spread of the pest to other parts of the country must be prevented. If it is necessary, the pest will be easily controlled with any organophosphate, carbamate or pyrethroid used for the control of other concurrent pests. The life cycle of the pest has to be investigated in future experiments.

AUTHOR'S CONTRIBUTION

The authors confirm their contribution to the paper as follows: M. Shayanmehr: Conducting the project, collecting, and identification of specimens, writing; E. Yoosefi Lafooraki: Rearing the specimens, writing; A. Shirvani: Confirming identification, writing; A. Bakhshi: Preparing materials, writing; F. Shahbaznejad: Collecting materials, writing; All authors read and approved the final version of the manuscript. The authors read and approved the final version of the manuscript.

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AVAILABILITY OF DATA AND MATERIAL

The specimens listed in this study are deposited in the insect collection of the Shahid Bahonar University of Kerman, Iran (SHBUK), and are available from the curator, upon request.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study only included plants and arthropod material, and all required ethical guidelines for the treatment and use of animals were strictly adhered to in accordance with international, national, and institutional regulations. No human participants were involved in any studies conducted by the authors for this article.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this paper.

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تهاجم اخیر پروانه گل مرکبات (*Prays citri* (Millière, 1873) (Lepidoptera: Praydidae) در ایران

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چکیده: لارو پروانه گل مرکبات معروف به بید مرکبات در حال تغذیه بر روی گل های درختان لیمو ترش (*Citrus limon*) در گلخانه های لیمو ترش در استان مازندران در اردیبهشت ۱۴۰۳ مشاهده شد. بر اساس ترجیح میزبانی و ویژگی های مورفولوژیک پروانه های بالغ، لاروها و شفیره ها، این آفت به عنوان گونه (*Prays citri* (Millière, 1873) (Lepidoptera: Praydidae) شناسایی شدند. طبق فهرست راهنمای پایش و ردیابی عوامل قرنطینه ای ایران در تاریخ یک تیر ۱۴۰۳، این آفت همچنان در فهرست آفات قرنطینه خارجی کشور قرار دارد. این گونه یکی از مضرترین آفات مرکبات به ویژه لیموترش است که به سرعت و به صورت خزنده در تمام مناطق جهان در حال گسترش است. شواهد اخیر ما حاکی از وجود این آفت در منطقه نسبتاً وسیعی از گلخانه های لیموی شمال ایران است. اطلاعات پس زمینه برای شناسایی قابل اعتماد از هر دو، حشره بالغ و لارو، تاریخ طبقه بندی، منشاء، پراکنش، گیاهان میزبان، آسیب، و شیوه های مدیریت آفت نیز مورد بحث قرار گرفت. وقوع این آفت، هشدار برای باغ های مرکبات ایران است و نشان دهنده خطر بالقوه شیوع آن به ویژه در مناطق جنوبی کشور نیز می باشد.

واژگان کلیدی: گونه مهاجم، آفات مرکبات، آفات قرنطینه خارجی، گلخانه، لیمو